Update to the Lightning Probability Forecast Equations at Kennedy Space Center/Cape Canaveral Air Force Station, Florida

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The 45th Weather Squadron (45 WS), located at Cape Canaveral Air Force Station (CCAFS) in Florida, provides daily 24-Hour and Weekly Planning Forecasts that include the probability of lightning occurrence. This information is used for general planning of operations at CCAFS and Kennedy Space Center (KSC). The lightning probability forecast had been based on a subjective analysis of model and observational data and the output from an objective lightning forecast tool developed by the Applied Meteorology Unit (AMU). This "Phase-I" tool consisted of a set of logistic regression equations that output a probability of lightning occurrence for the day on KSC/CCAFS during the thunderstorm season months of May–September. These equations outperformed several standard forecast methods that were used by forecasters and were transitioned into 45 WS operations in 2005. Two thunderstorm seasons occurred since the development of these equations and new ideas about certain predictors were formulated by the 45 WS. For Phase II, the AMU was tasked to update this tool by increasing the period of record to 17 years and modifying certain predictors to improve equation performance. The modifications included refining the forecast valid area, changing the method of determining the daily flow regime, using a new smoothing function for the daily lightning climatology curve, and optimizing the relative humidity layer.

The valid area for the lightning forecasts was reduced to only include the 5 n mi warning circles on KSC and CCAFS to match the area covered by the daily planning forecasts. This eliminated the western portion of the area used in the Phase I study, decreasing the values of the flow regime-based probability of lightning occurrence and the daily probability of lightning occurrence by 5–10%. The flow regimes for the Phase-I tool were determined using a combination of the average low-level wind direction in the morning soundings at Miami, Tampa, and Jacksonville, Florida. Almost 44% of the days in the period could not be classified. In Phase II, the new method included using the low-level wind direction from the morning sounding at CCAFS, and reduced the unclassified days from 44% to 12%. Because the Phase I raw daily probability of lightning occurrence and resulting thunderstorm season curve was quite noisy, the AMU modified the smoothing function. A common procedure to minimize the noisiness of a curve is to use a weighted average of the observations several days before and after the day of interest. A ±7-day Gaussian-weighted function used in Phase I to smooth the daily climatology curve still showed some noisiness. A ±14-day Gaussian function produced the smoothed daily lightning probability values used in Phase II. The average relative humidity (RH) in the 800–600 mb layer from the CCAFS 1000 UTC sounding was an important predictor for the Phase I tool. This parameter was deemed valuable to forecasting convection in the KSC/CCAFS area in studies conducted over 30 years ago. However, no rigorous attempts have been made to determine if the 800–600 mb layer is truly optimal. Using an iterative process, the AMU determined the optimal RH layer to be 825–525 mb and used it for the calculations in Phase II.

The new data and re-calculated predictors were used in the development of five new logistic regression equations, one for each month in the thunderstorm season, through careful selection and elimination of the candidate predictors. Their performance was tested against that of the previous set of equations and several other forecast benchmarks. The Phase-II tool showed an overall 8% increase in skill over the Phase-I tool. It also showed more reliability, an improved ability to distinguish between non-lightning and lightning days, and better accuracy measures and skill scores. Given the overall good performance, the 45 WS requested that the Phase-II tool be implemented for operational use in May 2007. The AMU also developed and delivered a graphical user interface that provides access to the equations for ease of use, speed, and accuracy.

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14. ABSTRACT

This conference presentation describes the improvement of a set of lightning probability forecast equations that are used by the 45th Weather Squadron forecasters for their daily 1100 UTC (0700 EDT) weather briefing during the warm season months of May-September. This information is used for general scheduling of operations at Cape Canaveral Air Force Station and Kennedy Space Center. Forecasters at the Spaceflight Meteorology Group also make thunderstorm forecasts during Shuttle flight operations. Five modifications were made by the Applied Meteorology Unit: increased the period of record from 15 to 17 years, changed the method of calculating the flow regime of the day, calculated a new optimal layer relative humidity, used a new smoothing technique for the daily climatology, and used a new valid area. The test results indicated that the modified equaitions showed and increase in skill over the current equations, good reliability, and an ability to distinguish between lightning and non-lightning days.

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